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Okamoto et al.

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(54) **VEHICLE CONTROL DEVICE**

(71) Applicant: **DENSO CORPORATION**, Kariya, Aichi-pref. (JP)

(72) Inventors: **Tsuyoshi Okamoto**, Kariya (JP); **Noriaki Ikemoto**, Kariya (JP); **Youhei Morimoto**, Nagoya (JP); **Yuutarou Itou**, Kariya (JP)

(73) Assignee: **DENSO CORPORATION**, Kariya (JP)

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(Continued)

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CPC ***B60W 10/06*** (2013.01); ***B60H 1/00899*** (2013.01); ***B60H 1/025*** (2013.01); ***B60W 10/30*** (2013.01); ***B60W 20/15*** (2016.01); *B60Y 2306/07* (2013.01); *Y10S 903/93* (2013.01)

(58) **Field of Classification Search**
USPC ..... 701/22, 102; 60/303, 286; 123/142.5 R, 123/142.5 E, 41.02; 429/120; 180/65.28, 180/65.29, 65.265, 65.285, 65.275; 322/14; 903/903, 930
See application file for complete search history.

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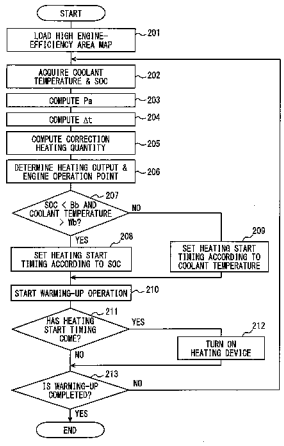
Primary Examiner — Cuong H Nguyen
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye PC

(57) **ABSTRACT**

A vehicle includes an engine, a first MG, a second MG, a main battery which can be charged and discharged, and a heating device. The heating device includes an exhaust heater which uses an exhaust heat of the engine, and a heat pump system which uses an electric power of the main battery. A hybrid control device determines a start timing of the heating device, based on a coolant temperature and a SOC. Specifically, the start timing of the heating device is determined such that a timing that the coolant temperature reaches a target temperature matches a timing that the SOC reaches a target value. After a warming-up operation is completed, an EV travelling of the vehicle can be executed according to the electric power of the main battery charged in the warming-up operation, and a fuel consumption of the engine is improved.

5 Claims, 9 Drawing Sheets



(51) **Int. Cl.**
B60H 1/00 (2006.01)
B60H 1/02 (2006.01)

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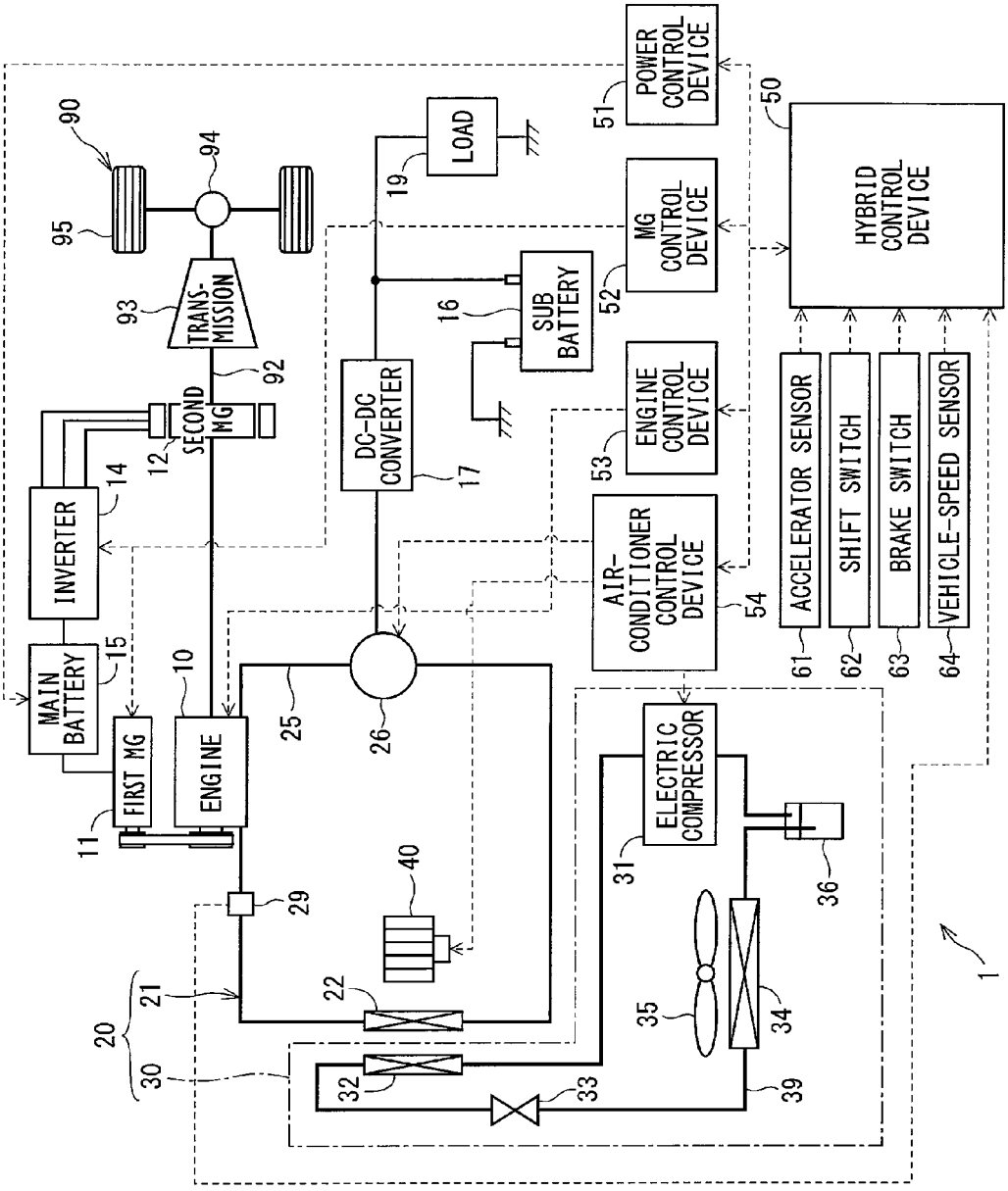

POWER CONTROL DEVICE
51
50
HYBRID CONTROL DEVICE
LOAD
19
MG CONTROL DEVICE
52
SUB BATTERY
16
ENGINE CONTROL DEVICE
53
AIR-CONDITIONER CONTROL DEVICE
54
ACCELERATOR SENSOR
61
SHIFT SWITCH
62
BRAKE SWITCH
63
VEHICLE-SPEED SENSOR
64
90
94
95
93
TRANS-MISSION
92
SECOND MG
12
14
INVERTER
DC-DC CONVERTER
17
MAIN BATTERY
15
10
FIRST MG
ENGINE
11
25
26
ELECTRIC COMPRESSOR
31
36
40
29
22
21
20
30
32
33
35
34
39
1

FIG. 1

FIG. 2

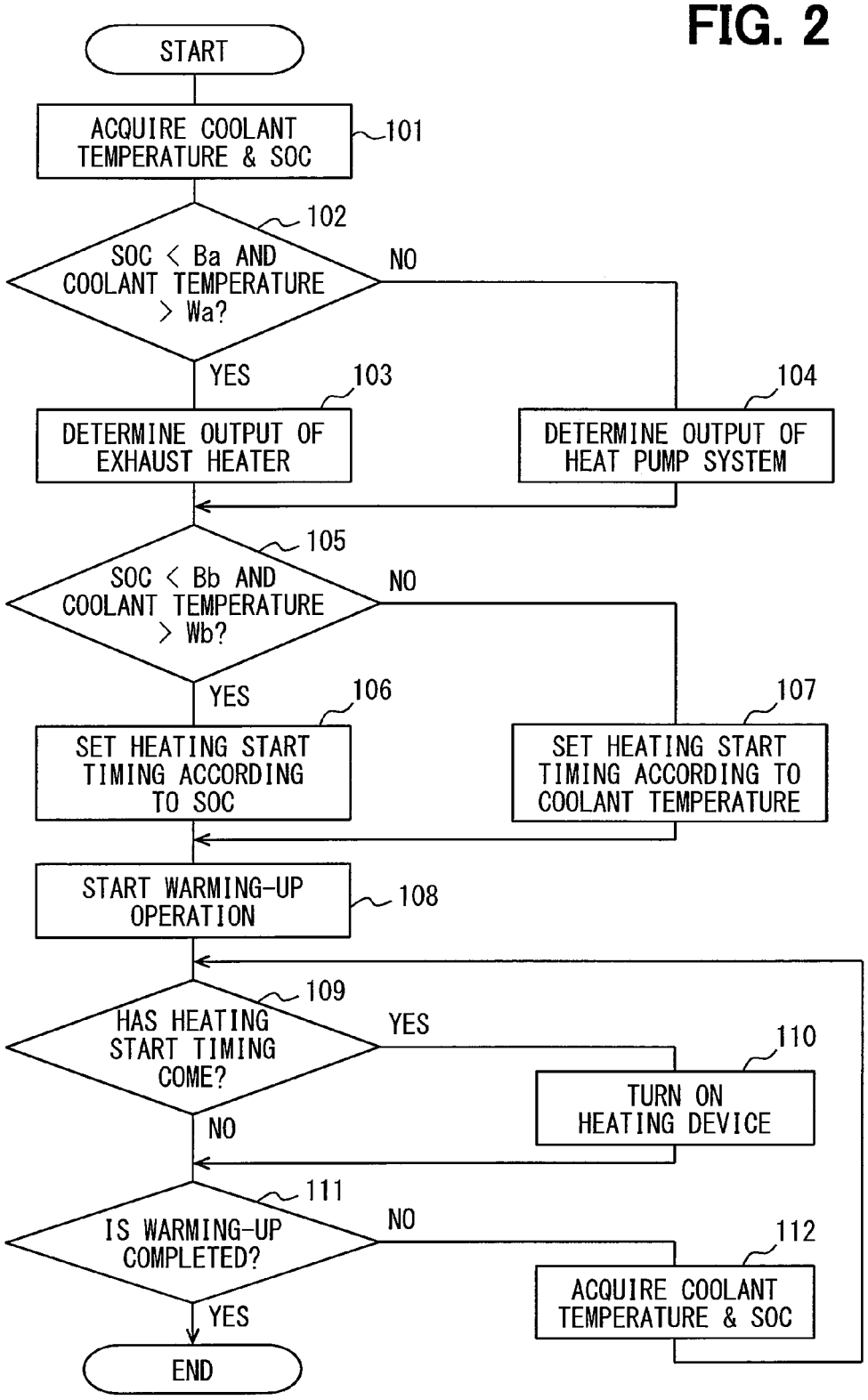

START
ACQUIRE COOLANT TEMPERATURE & SOC
101
102
SOC < Ba AND COOLANT TEMPERATURE > Wa?
NO
YES
103
DETERMINE OUTPUT OF EXHAUST HEATER
104
DETERMINE OUTPUT OF HEAT PUMP SYSTEM
105
SOC < Bb AND COOLANT TEMPERATURE > Wb?
NO
YES
106
SET HEATING START TIMING ACCORDING TO SOC
107
SET HEATING START TIMING ACCORDING TO COOLANT TEMPERATURE
START WARMING-UP OPERATION
108
109
HAS HEATING START TIMING COME?
YES
110
TURN ON HEATING DEVICE
NO
111
IS WARMING-UP COMPLETED?
NO
112
ACQUIRE COOLANT TEMPERATURE & SOC
YES
END

FIG. 3

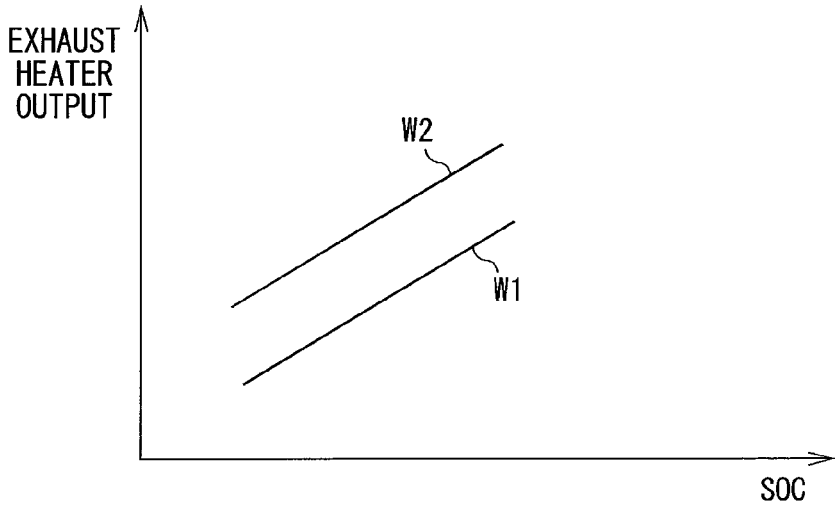

EXHAUST
HEATER
OUTPUT
W2
W1
SOC

FIG. 4

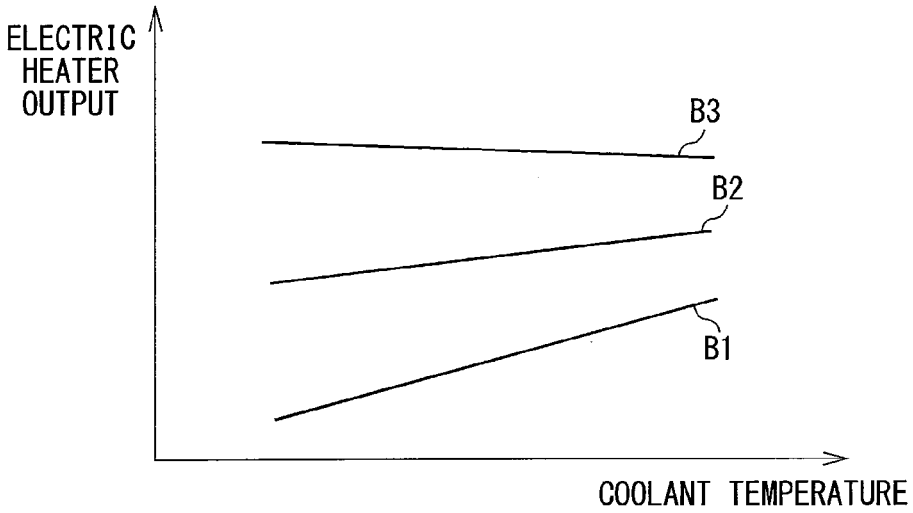

ELECTRIC
HEATER
OUTPUT
B3
B2
B1
COOLANT TEMPERATURE

FIG. 5

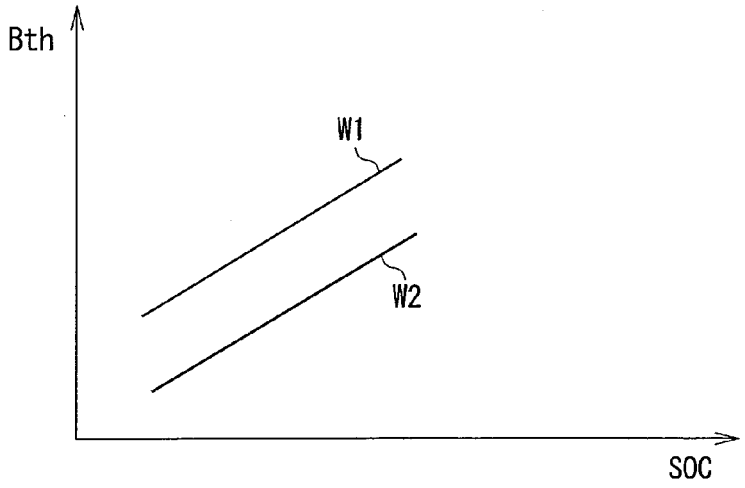


FIG. 6

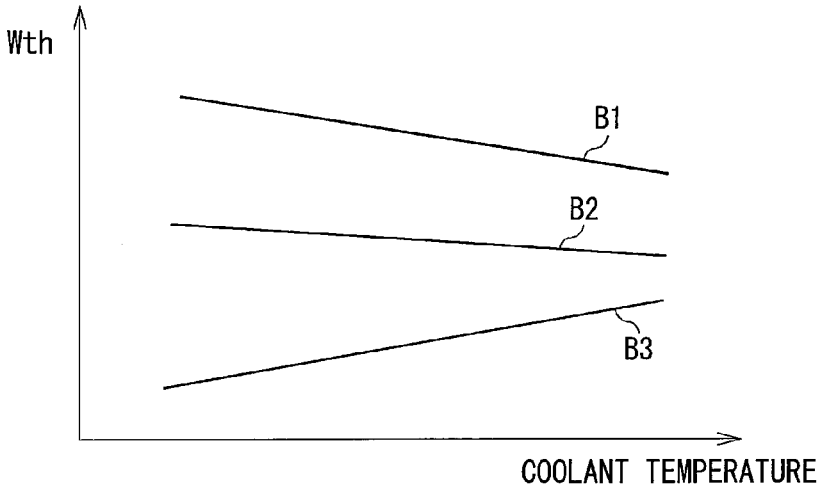


FIG. 7

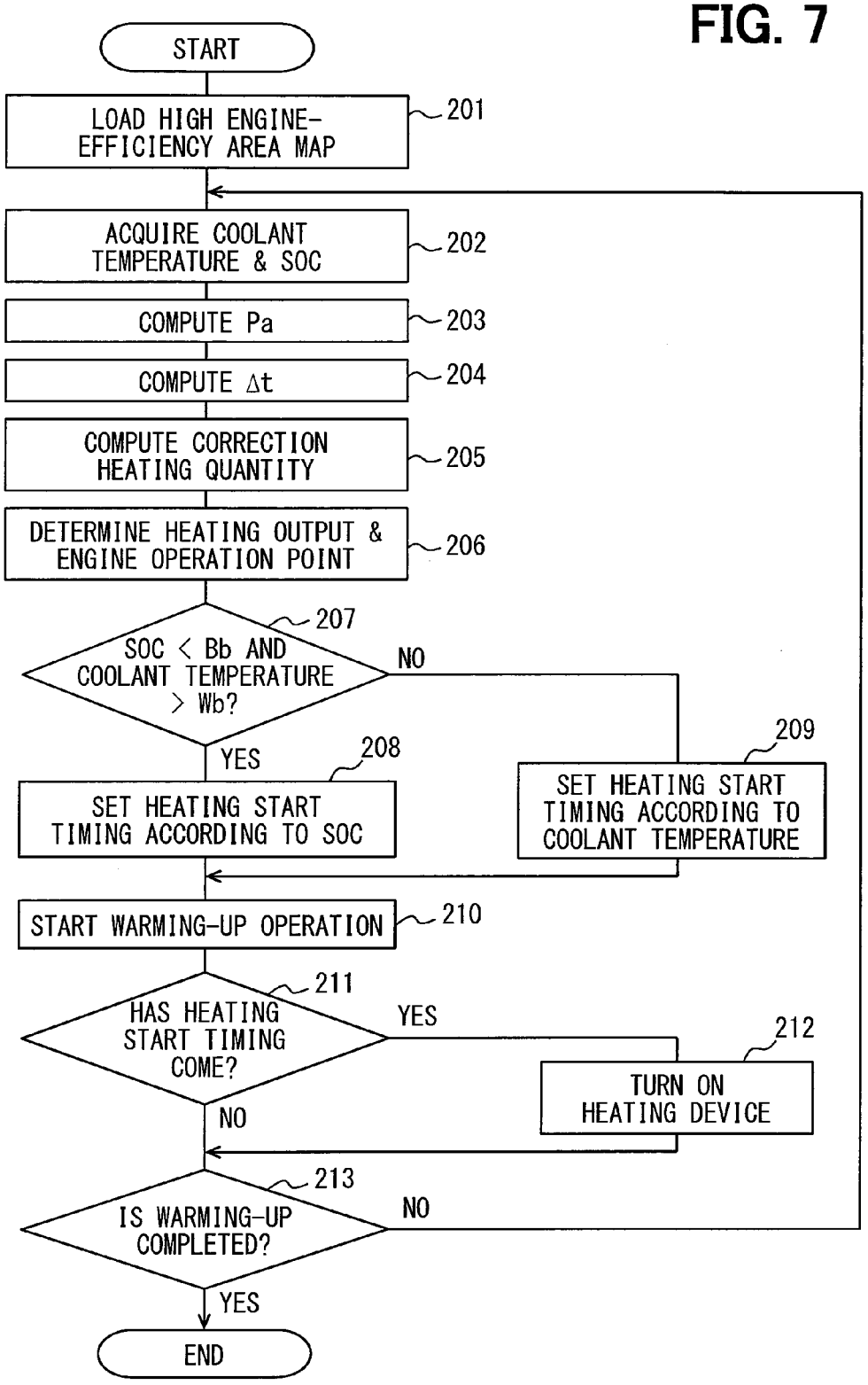

START
LOAD HIGH ENGINE-EFFICIENCY AREA MAP
201
ACQUIRE COOLANT TEMPERATURE & SOC
202
COMPUTE Pa
203
COMPUTE Δt
204
COMPUTE CORRECTION HEATING QUANTITY
205
DETERMINE HEATING OUTPUT & ENGINE OPERATION POINT
206
207
SOC < Bb AND COOLANT TEMPERATURE > Wb?
NO
YES
208
SET HEATING START TIMING ACCORDING TO SOC
209
SET HEATING START TIMING ACCORDING TO COOLANT TEMPERATURE
START WARMING-UP OPERATION
210
211
HAS HEATING START TIMING COME?
YES
NO
212
TURN ON HEATING DEVICE
213
IS WARMING-UP COMPLETED?
NO
YES
END

FIG. 8

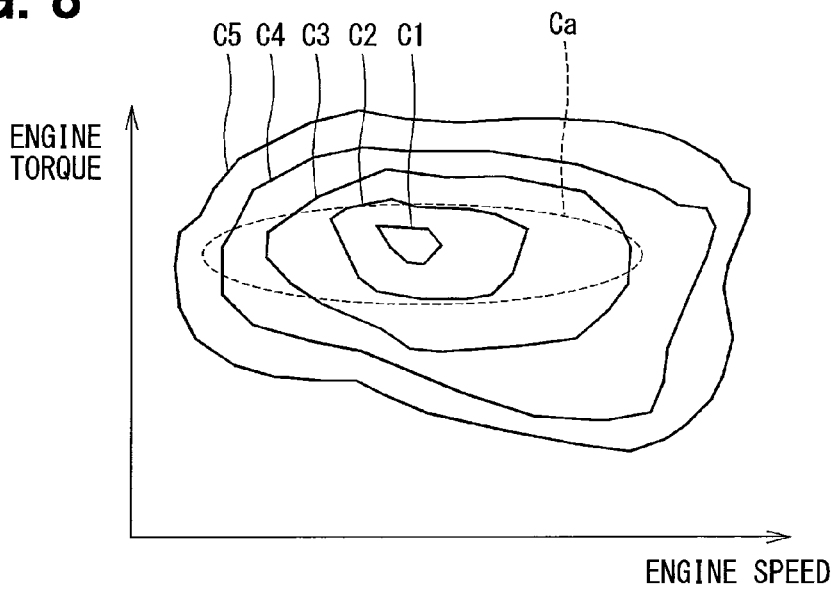

C5 C4 C3 C2 C1
Ca
ENGINE TORQUE
ENGINE SPEED

FIG. 9

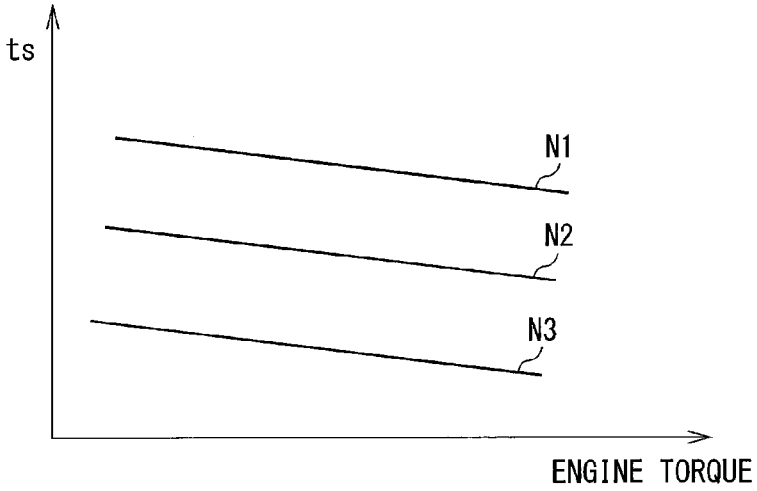

ts
N1
N2
N3
ENGINE TORQUE

FIG. 10

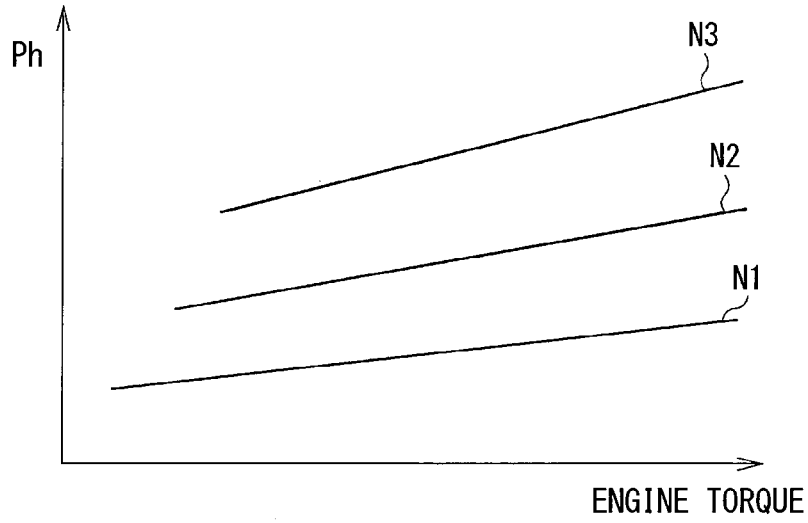


FIG. 11

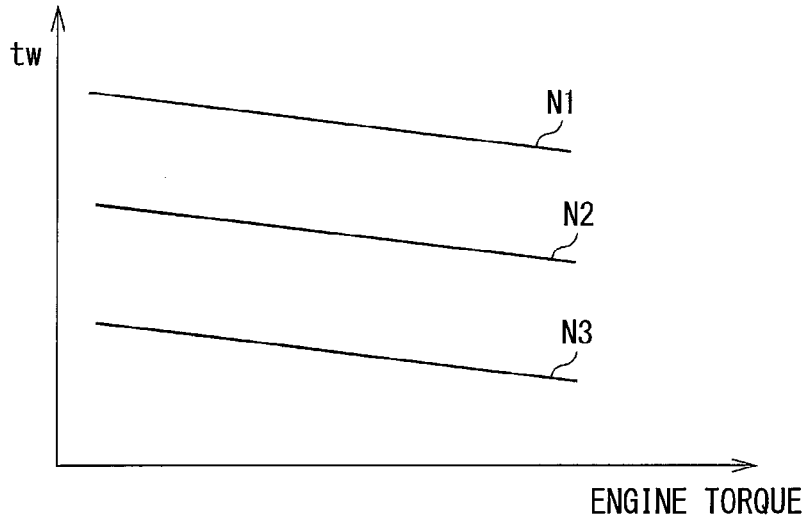


FIG. 12A

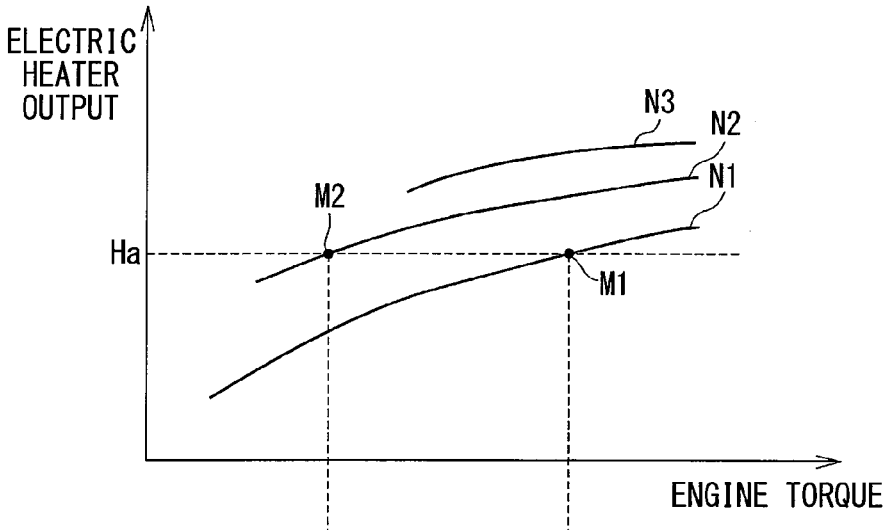


FIG. 12B

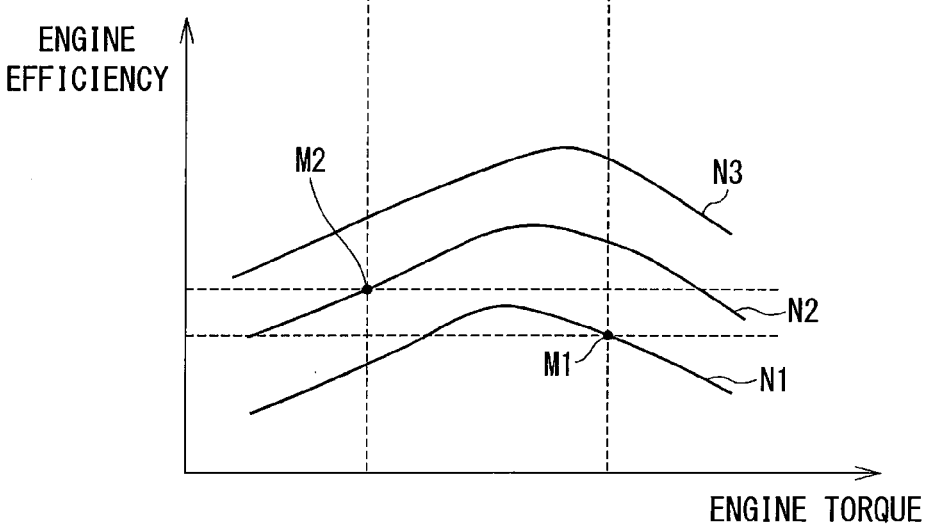


FIG. 13A

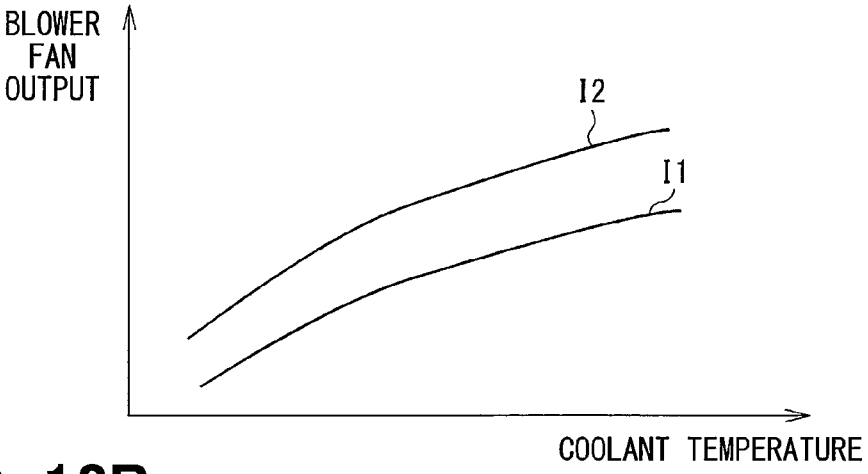


FIG. 13B

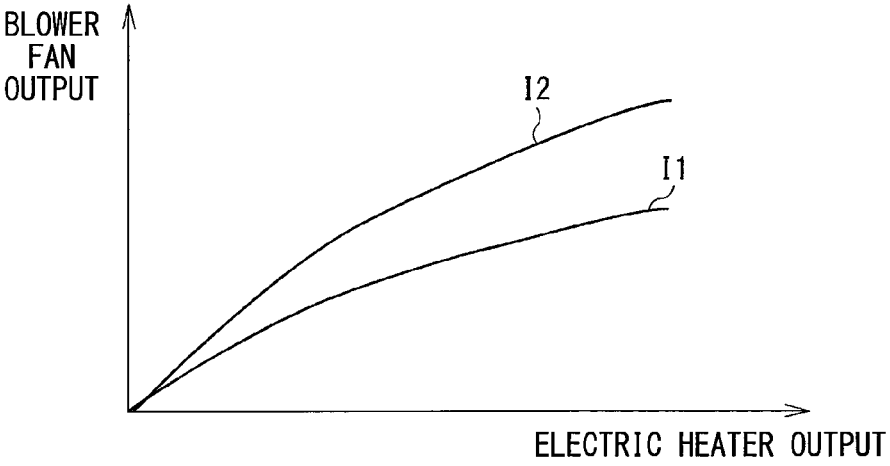
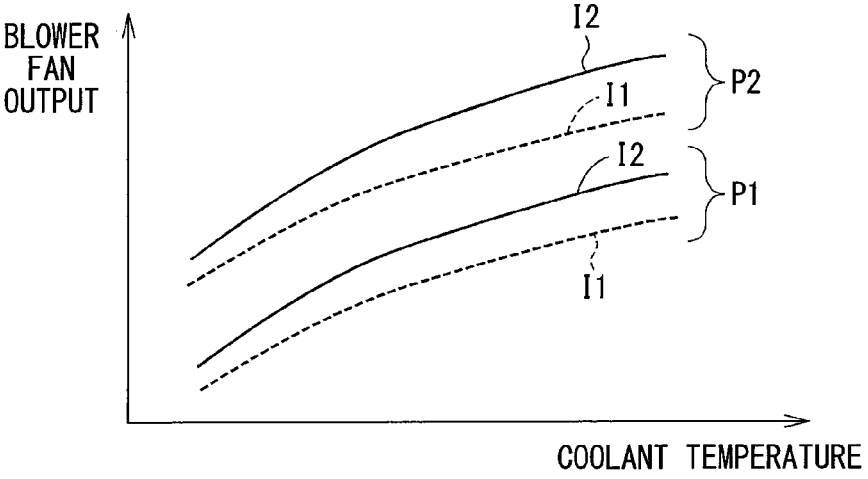


FIG. 13C



VEHICLE CONTROL DEVICE

CROSS REFERENCE TO RELATED APPLICATION

This application is based on Japanese Patent Application No. 2013-213552 filed on Oct. 11, 2013, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to a vehicle control device.

BACKGROUND

Conventionally, a heater core using an exhaust heat of an engine is well-known. According to Japanese Patent No. 3278919, when a heating is started in a case where a temperature of a coolant of the engine is low, a cold air flows to passengers. Therefore, when the temperature of the coolant is less than a predetermined temperature, the heating is not started.

However, in a vehicle provided with an exhaust heater and an electric heater which are used as heating devices, the optimum start timing of the heating cannot be determined only by the temperature of the coolant.

SUMMARY

The present disclosure is made in view of the above matters, and it is an object of the present disclosure to provide a vehicle control device which can properly determine a heating start timing in a hybrid vehicle provided with an exhaust heater and an electric heater which are used as a heating device.

According to the present disclosure, the vehicle control device controls the hybrid vehicle. The hybrid vehicle includes an engine, a motor generator, a power storage device, and a heating device. The power storage device receives an electric power from or transmits the electric power to the motor generator, and can be charged and discharged. The heating device includes an exhaust heater which uses an exhaust heat of the engine, and an electric heater which uses an electric power of the power storage device.

The vehicle control device includes a coolant-temperature acquiring portion, a power-residual acquiring portion, and a heating start-timing determining portion. The coolant-temperature acquiring portion acquires a temperature of a coolant of the engine. The power-residual acquiring portion acquires a power residual of the power storage device. The heating start-timing determining portion determines a start timing of the heating device based on the temperature of the coolant and the power residual.

According to the present disclosure, the start timing of the heating device is determined based on the temperature of the coolant and the power residual. Specifically, the start timing of the heating device is determined such that a timing that the temperature of the coolant reaches a target temperature matches a timing that the power residual reaches a target value. When the power residual is sufficiently large after a warming-up operation is completed, an EV travelling of the vehicle can be executed according to the electric power of the power storage device charged in the warming-up operation, and a fuel consumption of the engine is improved.

In a case where the power residual of when the warming-up is started is large, the heating is started by the electric heater before the warming-up is completed, and the electric power of the power storage device is used and charged. Therefore, the engine can operate at an efficient operation point without considering the power residual, and the fuel consumption of the engine is improved.

Since the heating device starts in the warming-up operation, comparing with a case where the heating device starts after the warming-up operation is completed, an inner temperature of the vehicle rapidly reaches a target inner temperature, and a comfortability is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

FIG. **1** is a block diagram showing a vehicle control system according to a first embodiment of the present disclosure;

FIG. **2** is a flowchart showing a warming-up control according to the first embodiment;

FIG. **3** is a graph showing a map determining an exhaust heater output according to the first embodiment;

FIG. **4** is a graph showing a map determining an electric heater output according to the first embodiment;

FIG. **5** is a graph showing a map determining a heating start SOC according to the first embodiment;

FIG. **6** is a graph showing a map determining a heating start temperature according to the first embodiment;

FIG. **7** is a flowchart showing the warming-up control according to a second embodiment of the present disclosure;

FIG. **8** is a graph showing an engine efficiency according to the second embodiment;

FIG. **9** is a graph showing a map determining a SOC measuring period according to the second embodiment;

FIG. **10** is a graph showing a heating power according to the second embodiment;

FIG. **11** is a graph showing a map determining a temperature measuring period according to the second embodiment;

FIGS. **12**A and **12**B are graphs showing maps determining an engine operation point according to the second embodiment; and

FIGS. **13**A, **13**B, and **13**C are graphs showing maps determining an output of a blower fan according to the second embodiment.

DETAILED DESCRIPTION

Embodiments of the present disclosure will be described hereafter referring to drawings. In the embodiments, a part that corresponds to a matter described in a preceding embodiment may be assigned with the same reference numeral, and redundant explanation for the part may be omitted. When only a part of a configuration is described in an embodiment, another preceding embodiment may be applied to the other parts of the configuration. The parts may be combined even if it is not explicitly described that the parts can be combined. The embodiments may be partially combined even if it is not explicitly described that the embodiments can be combined, provided there is no harm in the combination.

Hereafter, referring to drawings, a vehicle control device according to the present disclosure will be described. The substantially same parts and the components as the follow-

ing embodiments are indicated with the same reference numeral and the same description will not be reiterated.

First Embodiment

FIG. **1** is a block diagram showing a vehicle control system **1** to which a vehicle control device is applied, according to a first embodiment of the present disclosure. The vehicle control system **1** includes an engine **10**, a first motor generator **11**, a second motor generator **12**, a main battery **15** as a power storage device, a heating device **20**, and a hybrid control device **50** as the vehicle control device. Hereafter, the motor generator is referred to as MG.

The engine **10** is an internal combustion engine provided with multiple cylinders. The engine **10**, the first MG **11**, and the second MG **12** correspond to a driving power source of a vehicle **90**. According to the present embodiment, the vehicle **90** is a hybrid vehicle travelling according to a driving force of the engine **10**, the first MG **11**, or the second MG **12**.

The first MG **11** and the second MG **12** have an electric motor function that the first MG **11** and the second MG **12** are rotated by an electric power supplied from the main battery **15** to generate a torque, and a power generator function that the first MG **11** and the second MG **12** are driven by the engine **10** or by the vehicle **90** that is braked to generate the electric power. According to the present embodiment, both the first MG **11** and the second MG **12** are three-phase AC motors corresponding to permanent-magnet synchronous motors.

The first MG **11** is driven by the engine **10**, and is mainly used to generate the electric power. The electric power generated by the first MG **11** is supplied to the main battery **15** via an inverter that is not shown.

The second MG **12** is mainly used as an electric motor. The second MG **12** is power supplied from the main battery **15** via an inverter **14**. When the vehicle **90** is accelerated, the second MG **12** is used as the electric motor. When the vehicle **90** is decelerated, the second MG **12** is used as the power generator. In this case, the electric power generated by the second MG **12** is supplied to the main battery **15** via the inverter **14**.

The driving force of the engine **10** and the driving force of the second MG **12** are transmitted to a transmission **93** via a driving shaft **92**, and are further transmitted to a driving wheel **95** via a differential gear **94** to rotate the driving wheel **95**. According to the present embodiment, the transmission **93** is a continuously variable transmission.

The main battery **15** includes a rechargeable battery made of nickel hydride or lithium ion. The main battery **15** can be charged or discharged. A state of charge (SOC) of the main battery **15** corresponding to a power residual is controlled to be in a predetermined range. The main battery **15** receives the electric power from or transmits the electric power to the first MG **11** and the second MG **12**. Specifically, an AC power generated by the first MG **11** or the second MG **12** is converted into a DC power, and is stored in the main battery **15**. Then, the DC power of the main battery **15** is converted into the AC power, and is mainly supplied to the second MG **12**.

A sub battery **16** is battery outputting an output voltage that is less than an output voltage of the main battery **15**. The sub battery **16** is connected to the main battery **15** via a DC-DC converter **17**. Therefore, the sub battery **16** is chargeable according to an electric power stepped down by the DC-DC converter **17** from the electric power of the main battery **15**. The electric power of the sub battery **16** is supplied to devices which are driven by a low voltage, such as a load **19** or an electric pump **26**.

The heating device **20** includes an exhaust heater **21**, a heat pump system **30** as an electric heater, and a blower fan **40** as a blower.

The exhaust heater **21** includes a heater core **22**, a circulation passage **25**, and the electric pump **26**. The heater core **22** heat exchanges from a coolant of the engine **10** and supplies an exchanged heat to an interior of the vehicle **90**. The blower fan **40** sends air toward the interior of the vehicle **90**.

A water jacket is provided in a cylinder block of the engine **10** or a cylinder head of the engine **10**. The coolant is circulated through the water jacket to cool down the engine **10**. The water jacket communicates with the circulation passage **25** including a coolant pipe. The circulation passage **25** is provided with the electric pump **26**. The electric pump **26** is power supplied and driven by the sub battery **16** to circulate the coolant. A flow rate of the coolant circulating through the circulation passage **25** is adjusted by changing a discharge quantity of the electric pump **26**.

The circulation passage **25** extends from an outlet of the engine **10** toward the heater core **22**, and returns back to the engine **10** via the heater core **22**. The air sent from the blower fan **40** flows through the heater core **22**, and is heated by a heat exchange with the coolant to become a warm air. The warm air is supplied from an outlet of the blower fan **40** to the interior of the vehicle **90**. According to the above configuration, a heat quantity supplied from the coolant to the interior of the vehicle **90** via the heater core **22** is controlled by controlling the discharge quantity of the electric pump **26** and a driving state of the blower fan **40**.

A temperature sensor **29** is disposed at a position of the circulation passage **25** adjacent to the outlet of the engine **10**. The temperature sensor **29** detects a temperature of the coolant at a position between the outlet of the engine **10** and the heater core **22**. The temperature of the coolant is referred to as a coolant temperature.

The heat pump system **30** uses the electric power to supply the heat to the interior of the vehicle **90**. The heat pump system **30** includes an electric compressor **31**, an interior heat exchanger **32**, an expansion valve **33**, an exterior heat exchanger **34**, an accumulator **36**, and a refrigerant circulation passage **39** that includes a refrigerant pipe communicating with the above members.

The electric compressor **31** compresses and heats a refrigerant, and discharges a heated refrigerant toward the interior heat exchanger **32**. The electric compressor **31** is driven by the electric power supplied from the main battery **15** via the inverter that is not shown.

The interior heat exchanger **32** executes a heat exchange between the heated refrigerant discharged by the electric compressor **31** and a blowing air sent from the blower fan **40** toward the interior of the vehicle **90**. The blowing air flows through the interior heat exchanger **32** and is heated by a heat exchange with the heated refrigerant to become a warm air. The warm air is supplied from the outlet of the blower fan **40** to the interior of the vehicle **90**. In this case, the refrigerant is cooled down by the heat exchange with the blowing air. The refrigerant flowed through the interior heat exchanger **32** is decompressed by the expansion valve **33** and is discharged to the exterior heat exchanger **34**.

The exterior heat exchanger **34** is disposed at a position outside of the interior of the vehicle **90**. The exterior heat exchanger **34** executes a heat exchange between the refrigerant and an outer air. The outer air is sent to the exterior heat exchanger **34** by a radiator fan **35**. The refrigerant decom-

pressed by the expansion valve **33** is heated by a heat exchange with the outer air at the exterior heat exchanger **34**. The refrigerant heated by the exterior heat exchanger **34** is discharged to the electric compressor **31** via the accumulator **36**.

According to the present embodiment, the vehicle control system **1** further includes the hybrid control device **50**, a power control device **51**, an MG control device **52**, an engine control device **53**, and an air-conditioner control device **54**. The hybrid control device **50**, the power control device **51**, the MG control device **52**, the engine control device **53**, and the air-conditioner control device **54** are constructed by microcomputers each of which includes a CPU, a ROM, and a RAM, and execute programs stored in the ROMs to execute various controls.

The hybrid control device **50** receives signals from an accelerator sensor **61**, a shift switch **62**, a brake switch **63**, a vehicle-speed sensor **64**, and the temperature sensor **29**, and controls the vehicle **90** based on the signals.

The power control device **51** obtains the SOC of the main battery **15**, and monitors whether the SOC is in the predetermined range.

The MG control device **52** controls a driving of the first MG **11** or a driving of the second MG **12** based on a command of the hybrid control device **50**.

The engine control device **53** controls an operation of the engine **10** based on a command of the hybrid control device **50**. Specifically, the engine control device **53** executes an injection control of a fuel injector, an ignition timing control of an ignition device, a valve timing control of an intake valve-driving mechanism and an exhaust valve-driving mechanism, and an intake-quantity control of a throttle valve. Therefore, the operation of the engine **10** is controlled.

The air-conditioner control device **54** controls the blower fan **40**, the electric pump **26**, and the electric compressor **31**, based on a command of the hybrid control device **50**.

When the hybrid vehicle operates in a warming-up operation, it is necessary to increase an engine efficiency and to increase an engine output. Therefore, since the hybrid vehicle charges power and heats the coolant at the same time, a fuel consumption of the engine **10** can be improved. However, when the SOC reaches an upper limit, an output of the engine **10** cannot be increased. In this case, the engine **10** cannot be driven at a high efficiency.

According to the present embodiment, the heating device **20** is properly controlled based on the SOC of the main battery **15** in addition of the coolant temperature. Therefore, the engine **10** is driven at a high efficiency, and a warming-up can be completed at an early stage.

Referring to a flowchart shown in FIG. **2**, a warming-up control according to the present embodiment will be described. The warming-up control is executed by the hybrid control device **50** in a case where an ignition power is turned on.

At **101**, the hybrid control device **50** acquires the coolant temperature from the temperature sensor **29**. Further, the hybrid control device **50** acquires the SOC of the main battery **15**.

At **102**, the hybrid control device **50** determines whether both a first condition that the SOC is less than a first predetermined residual quantity Ba and a second condition that the coolant temperature is greater than a first predetermined temperature Wa are met. When the hybrid control device **50** determines that the first condition or the second condition is not met (**102**: No), the hybrid control device **50** proceeds to **104**. When the hybrid control device **50** determines that both the first condition and the second condition are met (**102**: Yes), the hybrid control device **50** proceeds to **103**.

At **103**, the hybrid control device **50** selects the exhaust heater **21** as the heating device **20**, and determines an output of the exhaust heater **21**. The output of the exhaust heater **21** is referred to as an exhaust heater output. The exhaust heater output is determined according to the SOC and the coolant temperature. According to the present embodiment, as shown in FIG. **3**, a map indicating a relationship between the exhaust heater output, the SOC, and the coolant temperature is established. The exhaust heater output is determined based on the SOC and the coolant temperature in reference to the map. As shown in FIG. **3**, a relationship between the SOC and the exhaust heater output is indicated in a case where the coolant temperature is W**1** or W**2**. In this case, the coolant temperature W**1** is less than the coolant temperature W**2**.

At **104**, the hybrid control device **50** selects the heat pump system **30** as the heating device **20**, and determines an output of the heat pump system **30**. The output of the heat pump system **30** is referred to as an electric heater output. The electric heater output is determined according to the SOC and the coolant temperature. According to the present embodiment, as shown in FIG. **4**, a map indicating a relationship between the electric heater output, the SOC, and the coolant temperature is established. The electric heater output is determined based on the SOC and the coolant temperature in reference to the map. As shown in FIG. **4**, a relationship between the coolant temperature and the electric heater output is indicated in a case where the SOC is B**1**, B**2**, or B**3**. In this case, B**1** is less than B**2**, and B**2** is less than B**3**.

The exhaust heater output and the electric heater output are set such that the SOC reaches a SOC target value Bg at a time point that the coolant temperature reaches a warming-up complete temperature Wg. At the time point that the coolant temperature reaches the warming-up complete temperature Wg, the warming-up is completed. According to the present embodiment, the warming-up complete temperature Wg corresponds to a temperature target value, and the SOC target value Bg corresponds to a power residual target value.

At **105**, the hybrid control device **50** determines whether both a third condition that the SOC is less than a second predetermined residual quantity Bb and a fourth condition that the coolant temperature is greater than a second predetermined temperature Wb are met. When the hybrid control device **50** determines that the third condition or the fourth condition is not met (**105**: No), the hybrid control device **50** proceeds to **107**. When the hybrid control device **50** determines that both the third condition and the fourth condition are met (**105**: Yes), the hybrid control device **50** proceeds to **106**.

At **106**, the hybrid control device **50** sets a heating start timing according to the SOC. Specifically, as shown in FIG. **5**, a map indicating a relationship between a heating start SOC threshold Bth corresponding to the SOC of when a heating is started, the SOC, and the coolant temperature is established. The heating start SOC threshold Bth is determined based on the SOC and the coolant temperature in reference to the map. As shown in FIG. **5**, a relationship between the SOC and warming-up start SOC threshold Bth is indicated in a case where the coolant temperature is W**1** or W**2**. In this case, the coolant temperature W**1** is less than the coolant temperature W**2**.

At **107**, the hybrid control device **50** sets the heating start timing according to the coolant temperature. Specifically, as shown in FIG. **6**, a map indicating a relationship between a

heating start temperature threshold Wth corresponding to the coolant temperature of when the heating is started, the SOC, and the coolant temperature is established. The heating start temperature threshold Wth is determined based on the SOC and the coolant temperature in reference to the map. As shown in FIG. **6**, a relationship between the coolant temperature and the warming-up start temperature threshold Wth is indicated in a case where the SOC is B1, B2, or B3. In this case, B1 is less than B2, and B2 is less than B3.

The heating start SOC threshold Bth and the heating start temperature threshold Wth are set such that the SOC reaches the SOC target value Bg at the time point that the coolant temperature reaches the warming-up complete temperature Wg. At the time point that the coolant temperature reaches the warming-up complete temperature Wg, the warming-up is completed.

According to the present embodiment, when the SOC is greater than or equal to the heating start SOC threshold Bth, the heating is started. Therefore, when the heating start SOC threshold Bth is determined, a heating-device start-timing is determined. The heating-device start-timing corresponds to a start timing of the heating device **20**. When the coolant temperature is greater than or equal to the heating start temperature threshold Wth, the heating is started. Therefore, when the heating start temperature threshold Wth is determined, the heating-device start-timing is determined.

At **108**, the hybrid control device **50** starts the warming-up operation of the engine **10**.

At **109**, the hybrid control device **50** determines whether the heating start timing has come. When the hybrid control device **50** determines that the heating start timing has not come (**109**: No), the hybrid control device **50** proceeds to **111**. When the hybrid control device **50** determines that the heating start timing has come (**109**: Yes), the hybrid control device **50** proceeds to **110**. Specifically, in a case where both the third condition and the fourth condition are met at **105**, (i) when the SOC is less than the heating start SOC threshold Bth, it is determined that the heating start timing has not come; (ii) when the SOC is greater than or equal to the heating start SOC threshold Bth, it is determined that the heating start timing has come. Alternatively, in a case where the third condition or the fourth condition is not met at **105**, (i) when the coolant temperature is less than the heating start temperature threshold Wth, it is determined that the heating start timing has not come; (ii) when the coolant temperature is greater than or equal to the heating start temperature threshold Wth, it is determined that the heating start timing has come.

At **110**, the hybrid control device **50** turns on the heating device **20**. Specifically, when the exhaust heater **21** is used as the heating device **20**, the hybrid control device **50** controls a flow rate of the electric pump **26** such that the exhaust heater output becomes the output of the exhaust heater **21** determined at **103**. Alternatively, when the heat pump system **30** is used as the heating device **20**, the hybrid control device **50** turns on the heat pump system **30** and controls the electric heater output to be the output of the heat pump system **30** determined at **104**. Further, the hybrid control device **50** turns on the blower fan **40**.

When the heating is started in a case where the coolant temperature is low, or when the heat pump system **30** is used in a case where the output of the engine **10** is low, it is necessary to reduce an output of the blower fan **40** so as to prevent cold air flowing toward passengers. The cold air is generated because a temperature of the outlet of the blower fan **40** is low.

At **111**, the hybrid control device **50** determines whether the warming-up is completed. When the coolant temperature is greater than or equal to the warming-up complete temperature Wg, the warming-up is completed. When the hybrid control device **50** determines that the warming-up is not completed, (**111**: No), the hybrid control device **50** proceeds to **112**. At **112**, the hybrid control device **50** reacquires the coolant temperature and the SOC, and returns to **109**. When the hybrid control device **50** determines that the warming-up is completed, (**111**: Yes), the hybrid control device **50** terminates the warming-up operation. According to the present embodiment, when the warming-up is completed, since the heating device **20**, the output of the heating device **20**, and the heating start timing are set such that the SOC reaches the SOC target value Bg, the main battery **15** is sufficiently charged. Therefore, after the warming-up is completed, the driving force of the second MG **12** is transmitted to the vehicle **90** such that the vehicle **90** travels in an EV travelling mode. Further, the vehicle **90** can travel in other modes other than the EV travelling mode, according to other information such as an accelerator position.

According to the present embodiment, even though the engine **10** operates in the warming-up operation, when the heating start timing has come, the exhaust heater **21** or the heat pump system **30** is started.

For example, when the SOC is small, the engine **10** is driven to increase an output in a high engine-efficiency area, and the main battery **15** is charged.

When the SOC is large, the heat pump system **30** is started even though the engine **10** operates in the warming-up operation, and an electric power of the main battery **15** can be used. The engine **10** is driven in the high engine-efficiency area, and the electric power of the main battery **15** is used while the main battery **15** is charged.

In a case where the coolant temperature is high and the SOC is small, when the main battery **15** is charged such that the SOC becomes the target value, the coolant temperature becomes excessively high, and it is possible to radiate heat from a radiator that is not shown to outer air. In this case, when the coolant temperature is less than the warming-up complete temperature Wg, the heating is started according to the exhaust heater **21**. Therefore, heat of the coolant can be transmitted to the interior of the vehicle **90**, and it is prevented that the heat is radiated to the outer air.

The engine **10** is driven in the high engine-efficiency area by changing the heating-device start-timing according to the coolant temperature and the SOC. Therefore, the main battery **15** is efficiently charged, the coolant temperature is efficiently increased, and the warming-up can be completed at an early stage. Thus, the fuel consumption of the engine **10** can be improved.

Further, the main battery **15** is charged in the warming-up operation. An EV travelling of the vehicle **90** can be executed according to the electric power of the main battery **15** after the warming-up is completed. Thus, the fuel consumption of the engine **10** can be further improved.

Furthermore, since the heating is started before the warming-up is completed, an inner temperature of the vehicle **90** rapidly reaches a target inner temperature, and a comfortability is improved.

The vehicle **90** includes the engine **10**, the first MG **11**, the second MG **12**, the main battery **15**, and the heating device **20**. The main battery **15** receives the electric power from or transmits the electric power to the first MG **11** and the second MG **12**, and can be charged and discharged. The heating device **20** includes the exhaust heater **21** which uses

an exhaust heat of the engine **10**, and the heat pump system **30** which uses the electric power of the main battery **15**.

The hybrid control device **50** controlling the vehicle **90** acquires the coolant temperature of the engine **10** and the SOC of the main battery **15** (**101**, **112**), and determines the heating-device start-timing based on the coolant temperature and the SOC (**106**, **107**).

According to the present embodiment, the heating-device start-timing is determined based on the coolant temperature and the SOC. The heating-device start-timing is determined such that a coolant timing that the coolant temperature reaches the warming-up complete temperature Wg matches a SOC timing that the SOC reaches the SOC target value Bg. When the SOC is sufficiently large after the warming-up operation is completed, the EV travelling of the vehicle **90** can be executed according to the electric power of the main battery **15** charged in the warming-up operation, and the fuel consumption of the engine **10** is improved.

In addition, when the coolant timing matches the SOC timing, it is unnecessary that the coolant timing is completely equal to the SOC timing. In this case, a time lag between the coolant timing and the SOC timing can be in a predetermined time. Since it is better that the SOC is increased such that the EV travelling of the vehicle **90** can be executed after the warming-up operation is completed, a state that the SOC reaches a predetermined value corresponds to a state that the coolant timing matches the SOC timing.

In a case where the SOC of when the warming-up is started is large, the heating is started by the heat pump system **30** before the warming-up is completed, and the electric power of the main battery **15** is used and charged. Therefore, the engine **10** can operate at an efficient operation point without considering the SOC, and the fuel consumption of the engine **10** is improved.

Since the heating device **20** starts in the warming-up operation, comparing with a case where the heating device **20** starts after the warming-up operation is completed, the inner temperature of the vehicle **90** rapidly reaches the target inner temperature, and the comfortability is improved.

The hybrid control device **50** determines a heating output corresponding to the exhaust heater output and the electric heater output in the warming-up operation, based on the coolant temperature and the SOC (**103**, **104**). According to the present embodiment, the heating output is determined such that the coolant timing matches the SOC timing.

Therefore, the heating device **20** is properly controlled such that the coolant timing matches the SOC timing. Since the SOC reaches the SOC target value in a case where the warming-up is completed, the EV travelling of the vehicle **90** can be executed after the warming-up operation, and the fuel consumption of the engine **10** is improved.

The hybrid control device **50** determines the output of the blower fan **40** sending air toward the interior of the vehicle **90**, based on at least one of the coolant temperature and the electric heater output (**110**). For example, when the heating is started in a case where the coolant temperature is low or the electric heater output is small, the output of the blower fan **40** is reduced to prevent cold air flowing toward the interior of the vehicle **90**.

According to the present embodiment, the hybrid control device **50** corresponds to a coolant-temperature acquiring portion, a power-residual acquiring portion, a heating start-timing determining portion, a heating-output determining portion, and a blowing-output determining portion. Further, as shown in FIG. **2**, operations in **101** and **112** correspond to the coolant-temperature acquiring portion and the power-residual acquiring portion. Operations in **106** and **107** correspond to the heating start-timing determining portion. Operations in **103** and **104** correspond to the heating-output determining portion. An operation in **110** corresponds to the blowing-output determining portion.

Second Embodiment

According to a second embodiment of the present disclosure, the warming-up control is different from that of the first embodiment.

Referring to a flowchart shown in FIG. **7**, the warming-up control according to the present embodiment will be described.

At **201**, the hybrid control device **50** loads a high engine-efficiency area map. As shown in FIG. **8**, the high engine-efficiency area map includes lines C**1** to C**5** each of which has operation points of the engine **10** where the engine efficiencies are the same. In this case, the operation points of the engine **10** may be engine speeds or engine torques. As shown in FIG. **8**, the line C**1** has the highest engine efficiency of the lines C**1** to C**5**, and the line C**5** has the lowest engine efficiency of the lines C**1** to C**5**. Further, the engine efficiencies of lines C**1** to C**5** have relationships that C**1** is greater than C**2** and C**2** is greater than C**3** and C**3** is greater than C**4** and C**4** is greater than C**5**. According to the present embodiment, an interior of the line C**3** is defined as the high engine-efficiency area.

Alternatively, an interior of a line Ca may be defined as the high engine-efficiency area. The line Ca has operation points of the entire system that considers the first MG **11**, the second MG **12**, and the main battery **15** instead of the engine **10**.

Alternatively, two or more high engine-efficiency maps may be defined according to travelling loads or vehicle speeds.

At **202**, the hybrid control device **50** acquires the coolant temperature from the temperature sensor **29**, and acquires the SOC of the main battery **15** via the power control device **51**.

At **203**, the hybrid control device **50** acquires the target inner temperature and a target period that the inner temperature reaches the target inner temperature, from the air-conditioner control device **54**, and computes an air-conditioner request output Pa. The unit of the air-conditioner request output Pa is kW. The air-conditioner request output Pa is computed according to an equation (1).

$$Pa=Ka\times(Rg-Rn)/tg \quad (1)$$

Ka indicates a specific-heat coefficient of air, and the unit of which is kJ/K.

Rg indicates the target inner temperature, and the unit of which is degree Celsius.

Rn indicates a current inner temperature, and the unit of which is degree Celsius.

tg indicates the target period, and the unit of which is sec.

At **204**, the hybrid control device **50** computes a SOC measuring period ts that the SOC reaches the SOC target value Bg, a temperature measuring period tw that the coolant temperature reaches the warming-up completer temperature Wg, and a difference between the SOC measuring period ts and the temperature measuring period tw as a measuring-period difference Δt.

The SOC measuring period ts is computer according to an equation (2). The unit of the SOC measuring period ts is sec.

$$ts=Ks\times(Bg-Bn)/Pg \quad (2)$$

Ks indicates a converting coefficient of the SOC to be converted into the electric power, and the unit of which is kJ/%.

Bg indicates the SOC target value, and the unit of which is %.

Bn indicates a SOC current value, and the unit of which is %.

Pg indicates a generation power, and the unit of which is kW.

The generation power Pg is computed according to an equation (3).

$$Pg=Pe-Lr-La \tag{3}$$

Pe indicates the engine output, and the unit of which is kW.

Lr indicates a travelling load, and the unit of which is kW.

La indicates an accessory load corresponding to a load of other accessories, and the unit of which is kW.

The SOC measuring period ts is previously computed according to the equation (2). Further, a map indicating a relationship between the SOC measuring period ts, the engine torque, the engine speed is established. FIG. **9** is a graph showing a relationship between the engine torque, the engine speed, and the SOC measuring period ts in a case where the travelling load Lr and the accessory load La are zero. Further, the engine speeds N**1**, N**2**, and N**3** have relationships that N**1** is less than N**2** and N**2** is less than N**3**. According to equations (2) and (3), since the SOC measuring period ts varies according to the travelling load Lr and the accessory load La, two or more maps are established at different travelling loads Lr and different accessory loads La. The SOC measuring period ts corresponds to a power-residual measuring period.

At **204**, the hybrid control device **50** selects the map based on the travelling load Lr and the accessory load La, and computes the SOC measuring period ts based on the engine operation point including the engine torque and the engine speed at a previous operation, and the map. The engine operation point may be an average point of a predetermined number of times of the engine operation points. Alternatively, the SOC measuring period ts may be directly computed according to equations (2) and (3).

The temperature measuring period tw is computed according to an equation (4). The unit of the temperature measuring period tw is sec.

$$tw=Kw\times(Wg-Wn)/Ph \tag{4}$$

Kw indicates a converting coefficient of the coolant temperature to be converted into the electric power, and the unit of which is kJ/K.

Wg indicates the warming-up complete temperature, and the unit of which is degree Celsius.

Wn indicates a current coolant temperature, and the unit of which is degree Celsius.

Ph indicates a heating power, and the unit of which is kW.

As shown in FIG. **10**, a heating-power map indicating a relationship between the heating power Ph, the engine torque, and the engine speed in the high engine-efficiency area is established. The heating power Ph is computed based on the engine torque and the engine speed.

The temperature measuring period tw is previously computed according to the equation (4). Further, a map indicating a relationship between the temperature measuring period tw, the engine torque, and the engine speed is established as shown in FIG. **11**. As shown in FIG. **11**, the engine speeds N**1**, N**2**, and N**3** have relationships that N**1** is less than N**2** and N**2** is less than N**3**, as the same as FIG. **9**.

At **204**, the hybrid control device **50** computes the temperature measuring period tw according to the map, based on the engine operation point including the engine torque and the engine speed which are determined at a previous operation. The engine operation point may be an average point of a predetermined number of times of the engine operation points. Alternatively, the temperature measuring period tw may be directly computed according to the equation (4). The temperature measuring period tw decreases in accordance with an increase in engine load.

Further, the hybrid control device **50** computes the measuring-period difference Δt between the SOC measuring period ts and the temperature measuring period tw, according to an equation (5).

$$\Delta t=|tw-ts| \tag{5}$$

At **205**, the hybrid control device **50** computes a correction heating quantity based on the measuring-period difference Δt. The correction heating quantity is used to make the coolant timing match the SOC timing.

When the temperature measuring period tw is greater than the SOC measuring period ts, a correction heating quantity H**1** outputted by the heat pump system **30** is computed according to an equation (6) to make the coolant timing match the SOC timing.

$$H1=Ks\times(Bg-Bn)/\Delta t \tag{6}$$

When the temperature measuring period tw is less than the SOC measuring period ts, a correction heating quantity H**2** outputted by the exhaust heater **21** is computed according to an equation (7) to make the coolant timing match the SOC timing.

$$H2=Kw\times(Wg-Wn)/\Delta t \tag{7}$$

At **206**, the hybrid control device **50** determines the heating output and the engine operation point.

According to the present embodiment, the hybrid control device **50** determines the heating output based on the correction heating quantity H**1** or the correction heating quantity H**2**. When the correction heating quantity H**1** is greater than an upper limit of the output of the heat pump system **30**, the electric heater output is set to the upper limit. When the correction heating quantity H**1** is less than or equal to the upper limit, the electric heater output is set to the correction heating quantity H**1**. When the exhaust heater **21** is used as the heating device **20**, the electric heater output is set as the same way as the above.

Further, the hybrid control device **50** determines the engine operation point which outputs the heating output. According to the present embodiment, when two or more engine operation points can output the heating output, the hybrid control device **50** selects the engine operation point having the highest engine efficiency.

FIGS. **12**A and **12**B are graphs showing maps determining the engine operation point. As shown in FIGS. **12**A and **12**B, the correction heating quantity is outputted by the heat pump system **30**.

As shown in FIG. **12**A, a map indicating a relationship between the electric heater output, the engine torque, and the engine speed is established. When the electric heater output is referred to as Ha, two points M**1** and M**2** exist as the engine operation points corresponding to the electric heater output Ha. In this case, referring to FIG. **12**B, the point M**2** has an engine efficiency higher than that of the point M**1**. Therefore, according to the present embodiment, the hybrid control device **50** selects the point M**2** as the engine operation point.

According to the present embodiment, when the air-conditioner request output Pa is greater than the correction heating quantity H1 or is greater than the correction heating quantity H2, one of the heat pump system **30** and the exhaust heater **21** that does not output the correction heating quantity outputs a shortage of the air-conditioner request output Pa. In this case, the shortage of the air-conditioner request output Pa is equal to a difference between the correction heating quantity H1 or H2 and the air-conditioner request output Pa. Specifically, when the correction heating quantity H1 is outputted by the heat pump system **30**, the exhaust heater **21** outputs the shortage of the air-conditioner request output Pa. When the correction heating quantity H2 is outputted by the exhaust heater **21**, the heat pump system **30** outputs the shortage of the air-conditioner request output Pa.

Operations in **207** to **212** correspond to operations in **105** to **110**. At **210**, the hybrid control device **50** changes an operation condition to continue the warming-up operation. Specifically, the hybrid control device **50** changes the operation condition to adjust the heating output and the engine operation point.

At **213**, the hybrid control device **50** determines whether the warming-up is completed. When the hybrid control device **50** determines that the warming-up is not completed (**213**: No), the hybrid control device **50** returns to **202**. When the hybrid control device **50** determines that the warming-up is completed (**213**: Yes), the hybrid control device **50** terminates the warming-up operation and executes the EV travelling.

According to the present embodiment, since the operations in **202** to **212** are repeated in the warming-up operation, the heating output and the engine operation point are corrected such that the SOC measuring period ts is equal to the temperature measuring period. Therefore, when the warming-up operation is completed, the SOC can reach the SOC target value Bg.

Referring to FIGS. **13**A, **13**B, and **13**C, the output of the blower fan **40** will be described. When the warming-up is started in a case where the coolant temperature is low, or when the heat pump system **30** is used as the heating device **20** in a case where the output of the engine **10** is low, it is necessary to reduce the output of the blower fan **40** so as to prevent the cold air flowing toward passengers.

As shown in FIG. **13**A, a map indicating a relationship between the output of the blower fan **40**, the coolant temperature, and a temperature of an intake air is established. Further, I1 and I2 indicate the temperatures of the intake air as example, and I1 is less than I2. When the hybrid control device **50** uses the exhaust heater **21** as the heating device **20**, the hybrid control device **50** determines the output of the blower fan **40** according to the map shown in FIG. **13**A based on the coolant temperature and the temperature of the intake air.

As shown in FIG. **13**B, a map indicating a relationship between the output of the blower fan **40**, the electric heater output, and the temperature of the intake air is established. Further, I1 and I2 indicate the temperatures of the intake air as example, and I1 is less than I2. When the hybrid control device **50** uses the heat pump system **30** as the heating device **20**, the hybrid control device **50** determines the output of the blower fan **40** according to the map shown in FIG. **13**B based on the electric heater output and the temperature of the intake air.

As shown in FIG. **13**C, a map indicating a relationship between the output of the blower fan **40**, the coolant temperature, the electric heater output, and the temperature of the intake air is established. Further, I1 and I2 indicate the temperatures of the intake air as example, and I1 is less than I2. Furthermore, P1 and P2 indicate the electric heater outputs as example, and P1 is less than P2. When the hybrid control device **50** uses both the exhaust heater **21** and the heat pump system **30** as the heating device **20** in a case where the air-conditioner request output Pa is large, the hybrid control device **50** determines the output of the blower fan **40** according to the map shown in FIG. **13**C based on the coolant temperature, the electric heater output, and the temperature of the intake air.

According to the present embodiment, when the warming-up is started in a case where the coolant temperature is low, or when the heat pump system **30** is used as the heating device **20** in a case where the output of the engine **10** is low, the output of the blower fan **40** is changed according to at least one of the coolant temperature and the electric heater output, so as to prevent the cold air flowing toward passengers. Since the outlet of the blower fan **40** can be warmed, the inner temperature can rapidly reach the target inner temperature in the heating after the warming-up even though the output of the blower fan **40** is low.

Further, the first embodiment has the same effect.

According to the present embodiment, the hybrid control device **50** specifies the high engine-efficiency area where the efficiency of the engine **10** is high, at **201**. The hybrid control device **50** determines the engine operation point that can output the heating output computed based on the coolant temperature and the SOC, at **206**.

Since the engine **10** can operate at the engine operation point with high efficiency without at the warming-up operation where the engine efficiency is inefficient due to a small load or no load, the fuel consumption of the engine **10** is improved.

When two or more engine operation points that can output the heating output determined based on the coolant temperature and the SOC exist, the hybrid control device **50** selects the engine operation point having the highest engine efficiency. Since the engine **10** can operate more efficiently, and the fuel consumption of the engine **10** is further improved.

According to the present embodiment, the hybrid control device **50** computes the correction heating quantities H1 and H2 based on the measuring-period difference Δt, and determines the heating output based on the correction heating quantity H1 or the correction heating quantity H2.

Therefore, the coolant timing can match the SOC timing.

Further, the first embodiment has the same effect.

According to the present embodiment, the hybrid control device **50** corresponds to the coolant-temperature acquiring portion, the power-residual acquiring portion, the heating start-timing determining portion, the heating-output determining portion, the blowing-output determining portion, a high engine-efficiency area determining portion, and an engine operation-point determining portion.

Further, as shown in FIG. **7**, an operation in **202** corresponds to the coolant-temperature acquiring portion and the power-residual acquiring portion. Operations in **208** and **209** correspond to the heating start-timing determining portion. An operation in **206** corresponds to the heating-output determining portion and the engine operation-point determining portion. An operation in **201** corresponds to the high engine-efficiency area determining portion. An operation in **212** corresponds to the blowing-output determining portion.

Other Embodiment

(a) According to the above embodiments, the electric heater includes the heat pump system. However, the electric

heater may be any heater using an electric power of a power storage device. For example, the electric heater may be a positive temperature coefficient (PTC) heater. Further, according to the above embodiments, the electric heater is used to heat the interior of the vehicle. However, the electric heater may be used to heat a coolant.

(b) According to the second embodiment, the air-conditioner request output is computed. When the heating output is less than the air-conditioner request output, both the exhaust heater and the heat pump system are used. However, the heating output may be determined without considering the air-conditioner request output in the warming-up operation.

(c) According to the above embodiments, the hybrid control device, the power control device, the MG control device, the engine control device, and the air-conditioner control device are provided. However, the above control devices may be united as one control device. Further, according to the above embodiments, the hybrid control device corresponds to the coolant-temperature acquiring portion, the power-residual acquiring portion, the heating start-timing determining portion, the heating-output determining portion, the blowing-output determining portion, the high engine-efficiency area determining portion, and the engine operation-point determining portion. However, control devices other than the hybrid control device may correspond to a part of or all of the above portions. For example, the engine control device may correspond to the engine operation-point determining portion.

(d) According to the above embodiments, the hybrid vehicle has two motor generators. However, the hybrid vehicle may have more than two motor generators. Further, according to the above embodiments, each motor generator is a three-phase AC motor corresponding to a permanent-magnet synchronous motor. However, the motor generator is not limited, and may have other configurations.

Furthermore, according to the above embodiments, the power storage device is a rechargeable battery. However, the power storage device may be any devices which receive the electric power from or transmit the electric power to the motor generator and can be charged and discharged. For example, the power storage device may be an electric double layer capacitor.

The present disclosure is not limited to the embodiments mentioned above, and can be applied to various embodiments within the spirit and scope of the present disclosure.

While the present disclosure has been described with reference to the embodiments thereof, it is to be understood that the disclosure is not limited to the embodiments and constructions. The present disclosure is intended to cover various modification and equivalent arrangements. In addition, while the various combinations and configurations, which are preferred, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the present disclosure.

What is claimed is:

1. A vehicle control device controlling a hybrid vehicle including an engine, a motor generator, a power storage device which receives an electric power from or transmits the electric power to the motor generator and can be charged and discharged, and a heating device which includes an exhaust heater using an exhaust heat of the engine and a heat pump system using the electric power of the power storage device, the vehicle control device comprising:

a memory for storing executable instructions; and

a processing system including a processor, the processing system upon execution of the instructions by the processing system being configured to:

acquire a temperature of a coolant of the engine;

acquire a power residual of the power storage device;

determine a start timing of the heating device based on the temperature of the coolant and the power residual; and

determine a heating output corresponding to an output of an electric heater and an output of the exhaust heater in a warming-up operation, based on the temperature of the coolant and the power residual, the heating output being determined such that a timing that the temperature of the coolant reaches a temperature target value matches a timing that the power residual reaches a power residual target value.

2. The vehicle control device according to claim **1**, wherein:

the processing system upon execution of the instructions is further configured to compute correction heating quantity based on a measuring-period difference, and determine the heating output based on the correction heating,

the measuring-period difference is a difference between a temperature measuring period and a power residual measuring period,

the temperature measuring period is a time that the temperature of the coolant reaches the coolant-temperature target value, and

the power residual measuring period is a time that the power residual reaches the power residual target value.

3. The vehicle control device according to claim **1**, wherein the processing system upon execution of the instruction is further configured to:

specify a high engine-efficiency area where an efficiency of the engine is high; and

determine an engine operation point that can output the heating output in the high engine-efficiency area.

4. The vehicle control device according to claim **3**, wherein

the engine operation point is selected as having the highest engine efficiency, when two or more engine operation points can output the heating output.

5. The vehicle control device according to claim **1**, wherein the processing system upon execution of the instructions is further configured to:

determine an output of a blower sending air toward an interior of the vehicle, based on at least one of the temperature of the coolant and the output of the electric heater.

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